Hindawi
International Journal of Ecology
Volume 2022, Article ID 5979024, 13 pages
https://doi.org/10.1155/2022/5979024

Research Article

Traditional Ecological Knowledge of Tribal Communities and Sustainability of Nature and Natural Resources in Pachmarhi Biosphere Reserve in India

Chandra Prakash Kala

Indian Institute of Forest Management, P.B. No. 357, Nehru Nagar, Bhopal 462003, India

Correspondence should be addressed to Chandra Prakash Kala; cpkala@yahoo.co.uk

Received 20 May 2022; Revised 25 November 2022; Accepted 1 December 2022; Published 8 December 2022

Academic Editor: Nathaniel Newlands

Traditional ecological knowledge (TEK) continues to erode as a result of globalization and the homogenization of diverse cultures, yet it has helped to conserve natural resources and preserve nature for centuries. Biosphere reserves have been established in regions where both cultural and natural resource assortments are deemed rich. The present study was carried out in the Pachmarhi Biosphere Reserve (PBR) of India with the major objective of investigating the TEK of local communities with respect to the sustainability of nature and natural resources. Through both a questionnaire and interviews with tribal groups in PBR, a total of 128 plant species were documented, of which the highest number of species (52%) was used for food, followed by medicine (40%), cultural practices (13%), and construction of houses (11%). Apart from the collection of plants from the adjacent forests for their sustenance, the tribal groups engaged in various other activities including farming practices, maintenance of home gardens, soil and water conservation, and continuance of sacred groves. The nature and natural resource-based livelihood and conservation activities of tribal groups involve specific cultural practices and customary norms. This study reveals that the traditional knowledge of tribal communities offers unique ideas for developing and contributing to more effective sustainable management practices and nature conservation. It has a great potential to strengthen the agriculture and health sectors, as the tribal communities have accumulated a fair amount of knowledge in such sectors.

1. Introduction

There are diverse knowledge perspectives on the use and sustainability of natural resources among communities across the world. One school of thought perceives anthropogenic activities as a major impediment for the sustainability of natural resources, to the extent that they may cause the sixth mass extinction of species [1, 2]. On the other hand, anthropocentrism advocates a strong human-centric approach for the utilization of natural resources, which is softened by introducing the concept of morality, while using other life forms [3–5]. Despite the diversity of opinions, there are commonalities among these philosophies in terms of ensuring the sustainability of various components of an ecosystem [6]. Even anthropocentric motivations are deemed to contribute positively in situations where humans are conscious of a direct benefit to themselves from a natural ecosystem [7].

Communities living historically in the proximity of these natural ecosystems, over a period of time, develop specific knowledge on the ecosystem and environmental resources that are later called as traditional knowledge or traditional ecological knowledge (TEK). TEK has been practiced since the ancient hunter-gatherer cultures; however, the term TEK as such was brought into extensive use in the 1980s [8]. At present, it denotes an integrated relationship between humans and ecosystems [9], and so that it is valued in a number of fields, including agriculture, pharmacology, ethnobotany, and sustainability of nature and natural resources [10, 11]. Besides, given the present environmental crisis, degradation of natural ecosystems, and climate change, TEK is being considered an important tool to

mitigate the effects of changing global environmental and ecological conditions, as it advocates the philosophy of coexistence and sustainability [12]. Being a set of unique local knowledge refined over the years, TEK helps to design practices for local level decision-making in agriculture, pastoralism, food preparation, health care, natural resource management, and a host of other activities [13–15].

The concept of ecosystem's sustainability becomes of utmost significance while utilizing its services by communities. The model of biosphere reserves, therefore, brings in to support both humans and nature by establishing sustainability support sites where baseline information on social and ecological systems is collected and changes and interactions between these two pivotal systems are studied [16]. Theoretical and applied studies on sociocultural and ecological interactions represent vital information for setting up priorities for sustainable development. Nonetheless, the interaction between the sociocultural and ecological dimensions of sustainable development remains largely less studied [17]. Through the realization of continuous erosion in TEK due to several reasons, including globalization and homogenization of diverse cultures, there is a need to study such a valuable knowledge in a holistic way that has supported to conserve the nature and natural resources for centuries. Biosphere reserves have been established in regions where both cultural and natural resource assortments are deemed rich. The present study was carried out in the Pachmarhi Biosphere Reserve (PBR) of India with the major objective of investigating the TEK of local communities with respect to the sustainability of nature and natural resources.

2. Study Site, Tribal People, and Survey Methods

2.1. Pachmarhi Biosphere Reserve. As part of the United Nations Educational, Scientific and Cultural Organization (UNESCO)'s initiatives under the Man and Biosphere Programmes, the Government of India initiated the National Biosphere Reserve Programme in 1986, and since then 18 biosphere reserves have been established in various parts of the country. The Pachmarhi Biosphere Reserve (PBR) was established on March 3, 1999. In reference to the biogeographic classification of India, the PBR is located in the Deccan Peninsula between 20° 10′ to 22°50′N latitude and 77°45′ to 78°56′E longitude in the Satpura Mountain Range of Madhya Pradesh state in India. PBR covers parts of Betul, Hoshangabad, and Chhindwara districts and spans over 4,926.28 sq km, of which 524.37 sq km is core zone and remaining 4,462.93 sq km comprises the buffer zone. It consists of three wildlife conservation units, the Satpura National Park (524.37 sq km), the Bori Wildlife Sanctuary (518.00 sq km), and the Pachmarhi Sanctuary (461.37 sq km; Figure 1). The land use pattern in PBR comprises forest (65.20%), agriculture (27.7%), water bodies (4.2%), wasteland (2.5%), and built-up land (0.5%). Of the total forest cover, the closed forest constitutes 85.3%, open forest 8.2%, and degraded forest 4.2% [18]. The most common tree species in the forests are *Tectona grandis, Chloroxylon swietenia*, and *Terminalia tomentosa* [19]. Besides rich biological and geographical diversity, the PBR endows with high cultural diversity as it is inhabited by number of tribal and nontribal communities [12]. A total of 575 villages are located inside the PBR consisting of 508 revenue and 67 forest villages [18]. The most dominant tribe in PBR is Gond.

2.2. Major Tribal Community

2.2.1. Gond. Gond ethnic groups are generally found in the states of Madhya Pradesh, Andhra Pradesh, Orissa, and Chhattisgarh [20]. In Madhya Pradesh, they are concentrated in the Satpura plateau consisting of Chhindwara, Hoshangabad, and Betul districts; PBR spans over these 3 districts only. They also live in parts of other districts like Mandla, Sioni, and Narasinghpur. The Gond tribe dominated the central parts of India; hence, it was known as Gondwana land. The social organization of the Gond reveals that they are divided into clans, including Bariba, Dhurwe, Erpachi, Imne, Kakoria, Padram, Sarbeyan, Sarada, Sivarsaran, Barkare, Barkey, Batti, Eke, Porta, and Tekam.

Gonds are polytheists and, hence, believe in number of gods and goddesses. Budhadeo is their major deity besides Bari Devi, Khedapati, Chotimata, Sidhababa, Gowalbaba, Bajrangbali, Bagdeo, Nagdeo, and Siyenebuda [12]. They have Padiar (shaman) and Bhomka (Priest) who perform various religious activities. The local people have their own calendar, which they use for different purposes, including the collection of forest resources and the cultivation of crops. At present, the major occupation of Gond revolves around agriculture and to some extent on the collection of minor forest produce and query labour work. The majority of them occupy some patch of agricultural land. They collect a range of forest produce from the local forest for consumption as well as for sale in the market.

2.2.2. Korku. Besides Gond, the PBR is inhabited by Korku tribe. Korku is believed to be an offshoot of Mawasi tribe. They inhabit all three districts covered under PBR. Being a hunter-gatherer community earlier, they used to live in the forests of Satpura mountain range [21]. They are divided into two subgroups (Raj Korku and Patharia Korku) and four territorial groups (Mawasi, Bawaria, Ruma, and Bondoya). In PBR, Bondoya Korku lives in Pachmarhi area and Bawaria in Betul district [19]. Korku, at present, practices agriculture and some of them are engaged in rearing livestock and collection of forest produce.

2.3. Survey Methods. Apart from collection of information through secondary sources, the primary surveys were carried out in the PBR. Ten villages situated in the buffer zone of PBR, namely, Bandi, Deokoh Bodalkachhar, Sawarwani, Shahwan, Fatepur, Singhpur, Anhoni, Khara, and Taperwani were selected for intensive study on TEK and nature conservation practices of tribal communities. The door-to-door questionnaire survey was conducted in the selected villages. Through a questionnaire survey and interviews, the information was collected on the indigenous uses of plant species, traditional farming practices, traditional knowledge on soil and water, and traditional nature conservation

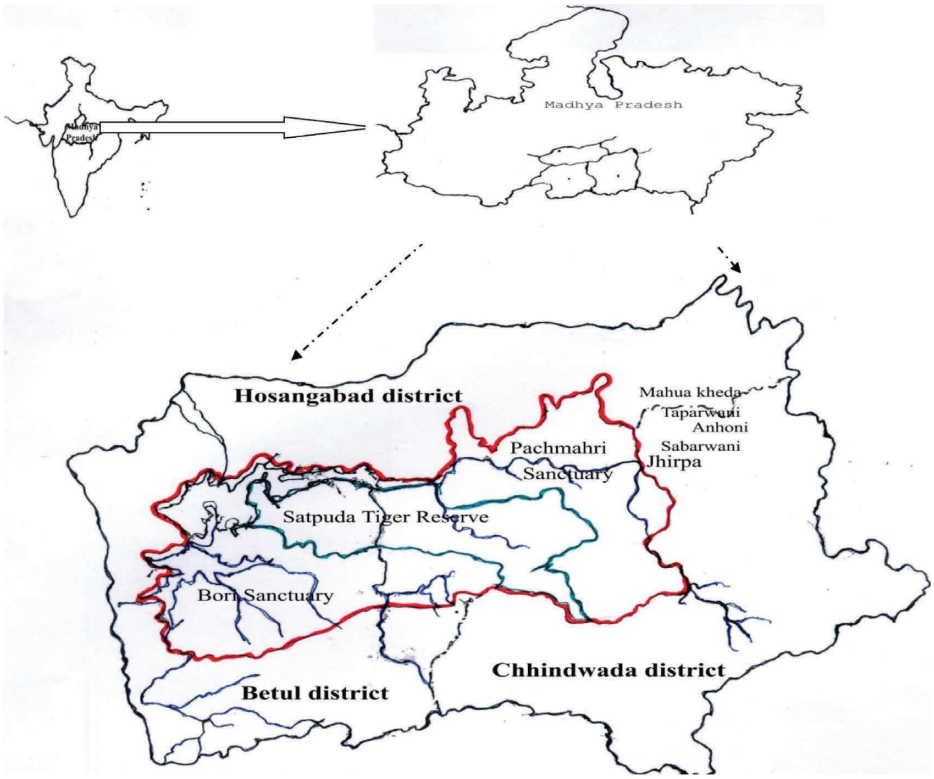

Figure 1: Location map of the Pachmarhi biosphere reserve in India.

practices and belief systems. Participant observations were also employed, and information was collected on various traditional practices with respect to the use of various natural resources by participating in cultural activities of the local tribal people. The cultural practices and norms for collection of various plant species and their parts along with rituals associated with farming and natural resource conservation were also documented through interviews and group discussions. The knowledgeable local people were also requested to accompany during the farm and forest surveys for identification of plant species and associated indigenous knowledge. Following the Nagoya Protocol [22], the ownership and control of the data as collected during the survey from the communities and described in this paper will remain with the tribal communities of PBR.

3. Results and Discussion

3.1. Tribal Forest Interactions. PBR harbors some thick forests in central India, which provide ample opportunities to its inhabitants for observing and scrutinizing various plant species and developing their own understanding and knowledge systems. Through questionnaires and interviews, a total of 128 plant species used for various purposes by the tribal communities living in the buffer zone villages of PBR are documented (Table 1). These species are distributed among various life forms. Of the total documented ethnobotanically important species, there are 55 tree species, 19 shrub species, 34 herbaceous plants (of which 16 are cultivated), 7 grasses, 5 climbers, 5 woody climbers, 2 under shrubs, and one fungus. These species are used for multiple purposes, of which the highest number of species (52%) are used for food, followed by medicine (40%), cultural practices (13%) and construction of houses (11%).

Different plant parts of ethnobotanical species are used as food, medicine, fodder, fish poisoning, oil making, and for preparing agricultural tools, brooms, plates, furniture, and ropes. Since the local people are mostly forest dwellers and traditionally depend on forests for food, they have developed very good knowledge on the use of food plant species. Of the total documented plant species, the fruits of the highest number of species (38%) are used by the local people, followed by leaves (25%), stems (18%), roots (15%), and seeds (11%). The important trees and their parts collected from the forests and nearby village areas by the local people are *Madhuca indica*, *Buchanania lanzan*, *Diospyros melanoxylon*, *Syzygium cumini*, *Terminalia chebula*, *Terminalia bellirica*, *Azadirachta indica*, and *Tamarindus indica*.

Madhuca indica, locally called as mahua, is one of the important plant species of tribal groups, as it is used for multiple purposes, including the prediction of weather and agriculture yields. While worshipping the mahua flowers in April and May, the colour of the flowers makes them predict some events. The agricultural production and amount of rainfall are assumed to be unaffected if the flower colour remains deep yellow. If it is light yellow and seems to be turning reddish, such phenomena make them believe that their crops are going to be infected by insects, which indicates a decline in agriculture production. They also believe that if the mahua does not flower at all, it indicates famine and is harmful to forest species.

The tribal people in PBR harvest plants by following some customary norms. Accordingly, the auspicious days

Table 1: Important plant species used by local people in selected villages of Pachmarhi biosphere reserve in India.

Sl. no.	Botanical name	Local	Habit	Part collected	Uses
1	*Acacia arabica* Willd.	Babul/bamur	Middle size tree	Stem	Fuel wood Construction of wheel of bullock carts Agricultural implements
2	*Acacia catechu* Willd.	Khair	Small tree	Stem Bark	House construction Fuel wood Husking tool (mussel) Medicinal (dysentery)
3	*Acacia nilotica* (L.) Willd. ex Del.	Subabool	Tree	Leaf Stem	Fodder Firewood
4	*Aegle marmelos* Correa.	Bel	Tree	Fruit Leaf	Edible Medicinal (stomach disorder) Religious (offer to goddesses)
5	*Aloe barbadensis* Mill.	Gourpatha	Herb	Leaf	Digestive, burnt, headache
6	*Andrographis peniculata* Nees.	Kadwa chirwa	Herb	Whole plant	Malaria
7	*Anogeissus latifolia* Wall.	Dhabda/Dhawra	Tree	Stem Resin	House construction Fuel wood Agriculture Selling
8	*Anogeissus pendula* Edgew.	Kala dhokda/Kardhai	Tree	Bark Stem Leaf	Medicinal (dysentery, cough) Firewood Fodders for cattle and goats
9	*Anona squamosa* L.	Sarifa/Sitaphal	Small tree	Fruit Leaf	Edible Ethno-veterinary use
10	*Anthistiria ciliata* L.	Ganeya grass	Grass	Whole	Fodder Fencing the land bunds Mulching
11	*Asparagus racemosus* Willd.	Satawari	Woody climber	Tuber Fruit	Medicine Oil (use in scabies)
12	*Azadirachta indica* A.H.L. Juss.	Neem/Lim	Tree	Leaf Bark Stem	Medicinal (malaria), Mosquito repellent Medicinal (fever) Toothbrush/toothache Fever Agricultural implement
13	—	Mushroom	Fungi		Edible
14	*Bauhinia purpurea* L.	Keolar	Small tree	Leaf	Vegetable
15	*Bauhinia variegata* L.	Kachnar	Small tree	Leaf	Edible
16	*Bauhinia vahlii* (W. and A.) Benth.	Mahul, malu	Woody climber	Leaf	Cup and plate making Rope making
17	*Berberis asiatica* Roxb. ex DC.	Daruhaldi	Shrub	Root	Medicinal (gynecological, inflamation)
18	*Bombax ceiba* L.	Semel, semra	Tree	Fruit	Medicine (boil) Chicken pox—it is used with kapoor to worship
19	*Boswellia serrata* Roxb.	Salei	Tree	Resin	Marketing

Table 1: Continued.

Sl. no.	Botanical name	Local	Habit	Part collected	Uses
20	*Buchanania lanzan* Roxb.	Achar/Chironji	Tree	Fruit	Edible
				Seed	Edible
21	*Butea monosperma* (Lam.) Kuntze	Palaas/Khakra	Tree	Leaf	Cup and plate making
				Stem	Cultural plant (thatched in marriage spot)
					Death ceremony/used during cremation
22	*Cajanus cajan* (L.) Millsp.	Tuar/Leher	Herb (cultivated)	Seed	Edible
23	*Calotropis gigantea* (L.) Dryander.	Akwa	Shrub	Leaf	Ethno-veterinary, muscle pain
				Flower	Worship of shiva
24	*Canavalia ensiformis* DC.	Semi/Barhar	Herb (cultivated)	Fruit	Edible
25	*Capsicum annum* L.	Mirch	Herb (cultivated)	Fruit	Edible
26	*Careya arborea* Roxb.	Kumbhi	Middle sized tree	Bark	Fish poisoning
27	*Casearia tomentosa* Roxb	Tundra/Tundri	Small tree	Fruit	Fish poisoning
28	*Cassia tora* L.	Chakoda	Herb	Leaf	Vegetable
				Fruit	Marketing
29	*Cedrela toona* Roxb.	Mahaneem	Tree	Stem	Furniture
					Boat
30	*Celastrus paniculata* Willd.	Unjain	Woody climber	Seed	Medicinal (cut and wound)
					Oil yielding
31	*Centella asiatica* L.	Brahmi	Herb	Leaf	Medicinal (stomach disorder, fever)
32	*Cissus quadrangularis* Wall.	Harjodi, hatjod	Climber	Stem	Medicinal (bone fracture)
33	*Chlorophytum tuberosum* Baker	Safed musli	Herb	Root	Medicinal (tonic)
34	*Chloroxylon swietenia* DC.	Ghiriha	Tree	Stem	House construction
					Agricultural implements
					Fuel wood
					Bullock cart
				Bark	Fish poison
					Mosquito repellant
35	*Cicer arietinum* L.	Chana	Herb (cultivated)	Seed	Edible
					Marketing
36	*Citrullus aromatica* Salisb.	Kacheria	Herb	Fruit	Edible
					Ethno-veterinary
					Chatni
37	*Citrus medica* L.	Nimbu	Small tree	Fruit	Edible
					Medicinal (stomach disorder, headache)
38	*Costus spaciosus* (Koenig ex Retz.) Smith	Keokand	Herb	Root	Tonic, stomach disorder
39	*Cryptolepis buchanani* Roem. and Schult.	Anatmul	Twining shrub	Root	Medicinal (gynecological)
					Tonic, used as tea
40	*Cucurbita maxima* Duch. ex Lam.	Kaddu	Herb (cultivated)	Fruit	Edible
41	*Curcuma aromatica* L.	Banhaldi	Herb	Root	Medicine (skin)
					Gynecological disorder
42	*Cynodon dactylon* (L.) Pearson	Dub	Grass	Whole plant	Cut and wound
					Cultural
43	*Delbergia paniculata* Roxb.	Dhobi	Tree	Root	Medicinal

Table 1: Continued.

Sl. no.	Botanical name	Local	Habit	Part collected	Uses
				Stem	House construction Door making
44	*Dendrocalamus strictus* Nees.	Bamboo	Grass		Cultural (making of "*Gatha*" to carry the dead body) Fishing trap Making of "*Thatri*" during village festival
				Twig	Edible (karla)
45	*Dillenia pentagyna* Roxb.	Agai	Middle sized tree	Fruit	Edible
46	*Dioscorea alata* L.	Ratalu	Climber	Rhizome	Edible Medicinal (stomach disorder)
47	*Dioscorea hispida* Willd.	Baichandi	Climber	Rhizome	Medicinal
48	*Dioscorea bulbifera* L.	Kadukand/Bhatadu	Climber	Rhizome	Edible
49	*Diospyros melanoxylon* Roxb.	Tendu	Tree	Fruit Leaf	Edible (ripe) Selling
50	*Embelia robusta* Roxb.	Brehmoniya/ Baibedang	Shrub	Bark	Medicinal (dysentery/fever/skin diseases)
51	*Sorghum bicolor* (L.) Moench	Jowar	Herb (cultivated)	Seed	Edible
52	*Ficus benghalensis* L.	Bargad	Tree	Fruit Leaf	Edible Fodder
53	*Ficus religiosa* L.	Peepal	Tree	Fruit	Edible
54	*Flemingia bracteata* Roxb.	Galphula	Shrub	Root	Gynecological (easy delivery of child)
55	*Garura pinnata* Roxb.	Kekad	Tree	Stem	Agricultural implements
56	*Gloriosa superba* L.	Kalihari	Herb	Root	Medicinal (scorpion sting) Conflict generating species between families Birth control/lady put it around the tammy
57	*Gmelina arborea* Roxb.	Kumbher	Tree	Fruit	Edible
58	*Guizotia abyssinica* Cass.	Jagni	Herb	Seed	Oil extraction Marketing
59	*Gymnema sylvestre* (Retz.) R. Br.	Gudmar	Woody climber	Root and twig	Medicinal (diabetes)
60	*Hamidesmus indicus* (L.) R. Br.	Dudhi bel	Twining shrub	Fruit	Edible
61	*Hardwickia binata* Roxb.	Anjan	Tree	Bark Stem	Rope making House construction
62	*Helicteres isora Linn.*	Athni	Shrub	Bark	Rope making
63	*Hibiscus cancellatus Roxb.*	Kacheli	Herb	Whole plant	Medicinal (debility and impotence)
64	*Holarrhena antidysenterica* Wall.	Dudhi	Tree	Fruit Seed	Medicinal (dysentery)
65	*Indigofera glandulosa* Willd.	Barbada	Herb	Stem	House construction Fuel wood
66	*Indigofera pulchella* Roxb.	Jirole	Shrub	Leaf	Vegetable
67	*Ipomea* sp.	Besaram	Shrub	Stem	Land boundary
68	*Ischaemum angustifolum* L.	Baber grass	Grass	Whole plant	House construction Rope making Broom making
69	*Ischaemum rugosum* Salisb.	Murdu/Murdi	Grass	Whole	Fodder Rope making

Table 1: Continued.

Sl. no.	Botanical name	Local	Habit	Part collected	Uses
70	*Jetropha curcas* L.	Rattanjot	Shrub	Fruit	Oil (applied on wound)
71	*Lagerstroemia parviflora* Roxb.	Lendia	Tree	Stem	Firewood Land boundary making
72	*Lantana camera* L.	Lantana	Shrub	Whole	Fencing of agricultural land
73	*Lawsonia alba* Lamk.	Hina, mehdi	Shrub	Stem	Fencing and making of bunds
74	*Leea macrophylla* Roxb.	Hathpan, hathikand	Herb	Root Leaf	Joint pain Vegetable
75	*Litsea sebifera* Persn.	Maida	Tree	Bark	Medicinal (diarrhea)
76	*Lycopersicum esculentum* Mill.	Tamatar	Herb (cultivated)	Fruit	Edible
77	*Madhuca indica* L.	Mahua/Guli	Tree	Flower Fruit Stem	Edible after cooking Liquor preparation/Offer to deities Oil (curry preparation) Massage in body Cultural (marriage)
78	*Manilkara hexandra* (Roxb) Dub. Syn: *Mimusops hexandra* Roxb.	Khirni	Tree	Fruit	Edible
79	*Melia azedarach* L.	Tuni	Tree	Seed	Fish poison
80	*Mangifera indica* L.	Aam	Tree	Fruit Seed Leaf	Edible (raw and ripe) Edible Marketing Cultural (making of marriage spot)
81	*Mimosa pudica* L.	Lajnu/Lajwanti	Under shrub	Whole plant	Medicine
82	*Mitragyna parviflora* (Roxb.) Korth.	Kem	Tree	Leafy branch	Cultural (marriage and death ceremony)
83	*Moringa pterygosperma* Gaertn.	Munga/Sahjan	Small tree	Leaf Fruit	Edible
84	*Mucuna pruriens* DC.	Keunch	Climber	Fruit	Snakebite
85	*Oryza sativa* L.	Dhan	Herb (cultivated)	Seed Straw	Edible Fodder
86	*Panicum colonus* L.	Sama	Herb (cultivated)	Seed	Edible
87	*Paspalum sanguinale* Lamk.	Rai	Herb (cultivated)	Seed Leaf	Oil Vegetable
88	*Paspalum scrobiculatum* L.	Kodu/Badheli/Kora	Herb (cultivated)	Seed	Edible after boiling Given after delivery
89	*Pennisetum purpureum* (DC.) Baker.	Chinni	Grass	Whole	House construction Broom making, rope making and cultural
90	*Peucedanum nagpurense* Prain.	Tejraj	Herb	Root	Tonic Blood purifier
91	*Phaseolus mungo* L.	Urad	Herb (cultivated)	Seed	Edible
92	*Phoenix sylvestris* Roxb.	Khajur	Tree	Fruit	Edible (ripe)
93	*Phyllanthus officinalis* L.	Amla	Tree	Fruit Leaf	Edible and medicinal (digestive) Cultural (offer to gods and goddesses)
94	*Plumbago zeylanica* L.	Chitawar, chitrak	Shrub	Root Leaf	Gynecological (easy delivery) (leprosy/Blood purification) Stomach disorder

Table 1: Continued.

Sl. no.	Botanical name	Local	Habit	Part collected	Uses
95	*Pongamia glabra* Vent.	Kanji/karanj	Middle sized tree	Fruit	Oil extraction
96	*Psoralea corylifolia* L.	Babchi/baxi	Herb	Fruit	Selling
97	*Psidium guava* L.	Jam/Amrud/Bihi	Tree	Fruit Leaf	Both raw and ripe fruits are eaten Medicinal (dysentery)
98	*Pterocarpus marsupium* Roxb.	Bija	Tree	Stem	House construction Furniture
99	*Randia dumetorum* Lamk.	Mainhar	Tree	Leaf	Vegetable
100	*Rauvolfia serpentina* L.	Sarpagandha	Under shrub	Fruit Root	Snake bite
101	*Ricinus communis* L.	Arandi	Shrub	Fruit Root	Oil (headache, massaging body) Easy delivery
102	*Schleichera trijuga* Willd.	Kusum	Tree	Fruit	Edible
103	*Semecarpus anacardium* L.	Bhelwa	Tree	Fruit	Edible Medicine (feet cracking)
104	*Sesamum indicum* L.	Til	Herb (cultivated)	Seed	Oil Edible
105	*Shorea robusta* Gaertn.	Sal/Sarei	Tree	Stem	House construction Furniture Fuel wood Plough making Cultural (to prepare marriage spot) Offer to deities for appeasement Tooth brush
				Resin	Medicinal (burn wound)
106	*Solanum nigrum* L.	Makoi	Herb	Fruit	Edible
107	*Solanum melongena* L.	Baigan	Herb (cultivated)	Fruit	Edible
108	*Stephegyne parvifolia* Korth	Kalam	Tree	Stem	Cultural (used during marriage)
109	*Sterculia urens* Roxb.	Gulhar/kullu	Tree	Resin Bark Stem	Medicinal (gynecological) Rope making Cultural (marriage)
110	*Syzygium cumini* (L.) Skeels	Jamun	Tree	Fruit Leaf Seed Bark	Edible Medicinal (dysentery) Cultural (placed on marriage spot) Medicinal (diabetic) Medicinal (dysentery)
111	*Tamarindus indica* L.	Emli	Tree	Fruit	Edible Pickle preparation Medicinal (ethno-veterinary) Selling
112	*Tectona grandis* L.	Sagaun	Tree	Stem	House construction Furniture Cultural (*Thatri* for worshipping deities are made of it)

Table 1: Continued.

Sl. no.	Botanical name	Local	Habit	Part collected	Uses
113	*Terminalia arjuna* Bedd.	Arjun/Koha	Tree	Stem Root	Firewood House construction Stomach disorder
114	*Terminalia bellerica* (Gaertn). Roxb.	Beheda	Tree	Fruit	Medicinal (digestive)
115	*Terminalia chebula* Retz. and Willd.	Harra	Tree	Fruit	Medicinal (digestive)
116	*Terminalia tomentosa* W&A	Saja	Tree	Stem	House construction Fuel wood Used during marriage
117	*Tinospora cordifolia* Miers.	Gurbel, Guduchi	Woody climber	Root Bark Leaf	Tonic Fever
118	*Triticum aestivum* L.	Ga	Herb (cultivated)	Seed	Edible Marketing
119	*Urginea indica* Kunth	Jangli piaz	Herb	Tuber	Ethno-veterinary
120	*Vaccaria pyramidata* Medik.	Musna	Herb	Flower	Ethno-veterinary
121	*Viscum nepalense* Willd.	Bandala	Semiparasitic shrub	Root	Medicinal
122	*Vitex negundo* L.	Nirgundi	Shrub	Whole	Fencing of agricultural land
123	*Vitiveria zizanioides* L.	Kash	Grass	Whole	House construction Rope making
124	*Woodfordia fruticosa* (L.) Kurz.	Dhawai	Shrub	Flower	Red dye, medicine
125	*Zea mays* L.	Makka	Herb (cultivated)	Seed	Edible
126	*Zizyphus jujuba* Lam.	Ber/Renga	Tree	Fruit	Edible
127	*Zizyphus xylopyra* Willd.	Ghont	Shrub	Bark	Agricultural implements House construction
128	*Zizypus rugosa Lamk.*	Churnachitu	Shrub	Leaf Fruit	Malaria Edible

are limited for such collections of plants from the wild. Besides, the extraction of forest resources depends on seasonal variations. During February and March, the gum of *Anogeissus latifolia* is tapped, which is followed by gathering of *Madhuca indica*'s flowers during March and April. Since *Madhuca indica* bears fruits during April and May, hence, they are picked up apart from gum of *Acacia nilotica* and *Terminalia tomentosa*. Depending on availability, the fruits of *Balanites roxburghii* are gathered during May and those of *Buchanania lanzan* during May and June [23, 24]. The collection of forest produce is made for both domestic consumption and selling out in the market. About twenty plant species are traded to the prospective buyers. The gum has high demand in the market; hence, its trade is the highest among all other forest produce [24].

Over time, the increasing demand of such forest produce in the market has invited unsustainable harvesting practices of tradable forest produce to get maximum returns. For instance, earlier, artificial incisions were generally avoided for tapping gums from *Anogeissus latifolia* as during summer the gum naturally oozes out [25]. At present, artificial incision is common for tapping of gum. In addition, to extract maximum quantity of gums, people begin to drill the trunk for making a deep hole which is injected with chemicals such as ethephon. Ethephon being a plant growth regulator is widely used as ethylene-releasing plant regulator in agriculture to promote fruit ripening, abscission, flower induction, and other responses [26]. The debarking of trees for such purposes and also for collection of bark for making herbal medicines have become a regular practice leading to premature death of tree species. Moreover, the collectors are less concerned about the traditional harvesting norms of species; hence, they have started to harvest forest produce before time, which subsequently hamper the growth and productivity of such important produce.

3.2. Farming by Tribal Communities. Apart from collection of forest produce from the wild, the tribal communities grow plant species in their agriculture land and home gardens. They raise crops in both plain and sloppy land areas. In agriculture land, they practice two types of cropping systems: rabi and kharif. The kharif cropping season starts in June and ends in October, whereas the rabi cropping season begins in October and ends in March. The major crops grown in both rabi and kharif seasons are different. In kharif season, the major crops grown include *Oryza sativa*, *Glycine max*, *Sorghum vulgare, Zea mays, Cajanus cajan, Vigna mungo*, and *Sesamum indicum*. In the rabi season, people mainly cultivate *Triticum aestivum*, *Cicer arietinum, Lens culinaris, Brassica campestris*, and *Pisum sativum* [27].

The agricultural activities are accomplished by performing some specific cultural practices. They celebrate some festivals with rich and vibrant ceremonies before and after growing and harvesting of crops. In the first sowing of seeds, they dig a hole in a corner of the agricultural land where they sow some traditional varieties of cultivated crops, followed by offering a coconut and a cup of "mahua liquor" to the "Sayenibuda," a local deity [12]. This practice is performed only once in a year and is not repeated for each sowing. Once the crops are ready to harvest, the head of the household offers some milk and mahua liquor to the "Sayenibuda" right in a crop field and thereafter harvesting of crop is allowed.

Bio-fencing is also made by erecting branches of some plants including nirgundi (*Vitex nigundo*) at the boundary of the crop fields. Besides, they perform some rituals in anticipation of protecting their crops. If the crops are infected by insects, they fix a branch of *Semacarpus anacardium* in the day of lunar eclipse with the belief that it helps to decline or remove the insects [27]. Traditionally, they also spray ashes of woods around the agricultural field for keeping insect pests away from the crops. When the crops are affected by unidentified diseases, a handful of un-boiled rice is picked up and brought by a male member of each household to the "Khedapati" temple, where they all gather with "Bhomka," a local priest. "Bhomka" worships the village deities to protect the crops from any misfortune. At the end of the ritual, each person offers a handful of rice to the village deities. This ritual is known as "Ujagar."

Apart from raising crops in agriculture land, they also grow and maintain plant species in the vicinity of their dwelling places, which is called as home gardens. About 47 species ranging from forestry to horticulture and agricultural are documented those are grown in the home gardens by the local people in buffer zone villages of PBR [28]. These species are used for multiple purposes including food, medicine, vegetables, nutraceutical, fodder, and cultural significance. The practice of raising home gardens was based on the centuries of cumulative traditional knowledge, practices and beliefs with respect to the multiple uses of species, and their environmental and ecological significance. The agriculture system of tribal communities is well knitted with their cultures and customs.

There has been a transformation in the traditional agricultural practices as earlier the inhabitants of PBR were also known to practice shifting cultivation; however, at present, they are practicing settled agriculture. Over the years, the introduction of hybrid seeds has declined the land races of indigenous crops. The traditional cow dung-based organic farming is mainly transformed to market driven chemical fertilizers. Continuous application of chemical fertilizers has exhausted the soil fertility affecting the quality of crops and their productivity. The voices are now raised to return to the traditional organic or ecological farming systems.

3.3. TEK on Soil and Water. Traditionally, the tribal in PBR have classified the soil types mainly on the basis of soil texture, soil colour, and moisture retaining capacity of soil. A total of 16 soil types, as classified by the tribes, are documented. These soil types are Bhurbhuria, Chikti, Kadialtori, Kamkaltori, Potini, Chikni, Kasai, Dadra, and Barrimitti. The selection of crops as grown in various soil types is mainly based on the soil moisture and soil types [29]. Some land races of *Oryza sativa* and *Triticum aestivum* including *Cicer arietinum* are relatively long duration crops and require high

moisture, whereas other land races of rice such as "Lalei" and "Batra" are of shorter duration and require less moisture. In the presence of high moisture contents, farmers avoid seeds sowing till moisture decreases to the desired level. Some of the farmers raise paddy nurseries for transplantation, and "bhurbhuria" soil type is generally preferred for raising such nurseries. The plantlets of paddy grow well and can also be uprooted easily if grown in "bhurbhuria" soil.

Traditionally, the tribal communities often test the quality and usefulness of soil for raising crops by mixing water in it. If the soil easily mixes with water, it is considered less fertile. If the water is absorbed slowly by the soil, such soil is believed to have good quality and is useful for raising crops. Besides agricultural purposes, the soil is used for making houses, pots, whitewashing, and painting. They use 3 different soil types such as Lalmitti (red soil), Pirmitti (black soil), and Chhuimitti (whitish soil) for decoration of houses [12]. Traditionally, the tribal communities generally believe that water coming from ground is purer than other sources. The rivulet water is used for religious purposes. Besides, such running water that flows through various forests and ecosystems having valuable medicinal plants is considered good for health due to intermingling of some medicinal properties.

In view of the declining soil fertility due to the continuous and heavy use of chemical fertilizers, soil testing laboratories have been established to analyze the soil quality and subsequently improve and maintain the soil fertility. Krishi Vighyan Kendra (Agricultural Science Centre) in Betul, Hoshangabad, and Chhindwara issue soil health cards to the farmers after testing their farms' soil. Preparing soil health cards is an attempt to revitalize the natural ecological attributes of the soil by suggesting timely interventions to the farmers [30]. For sustainable crop productivity, soil health card-based management is considered an efficient management system [31].

3.4. TEK and Sustainability of Nature and Natural Resources. The planet Earth and its various components including, rivers, water, hills, forests, birds, animals, and plants are inseparable from the lives of tribal people, as their knowledge, folklore, and culture are closely knit and based upon such natural resources. Their belief in living with present rather than saving for future has made them to refrain from overexploitation of resources, as there was no dearth of natural resources in the past for daily sustenance and they were sure on the plenty of resource availability by the grace of God.

Despite the traditional belief in the tribal society of PBR that the forest is as eternal as the Earth and the universe, traditionally, they develop and follow some customary norms while gathering plants. During monsoon, Gond tribes, generally, avoid harvesting of plants for medicine realizing that monsoon is the period of growth and additions of new individuals in the existing populations. Only a few specific days and period are considered auspicious to collect the medicinal plants. For example, the ninth day of Navratri (Goddess Durga festival that spans consecutive nine nights), full moon night or moon less night, and Tuesday and Saturday are considered auspicious for plant collection in the genuine cases. Locally, it is called "jari-jagana," which literally means to wake up or activate the plant. Only "Bhumka" is authorized to cut down the plant on Wednesday or Sunday. Medicinal plants are mainly collected before sunrise after taking bath.

The tribal people in PBR do not remove all the trees while practicing agriculture, and let some trees grow in the agriculture land, especially useful species such as *Madhuca indica*. The availability of tree species in the farmland, besides providing organic matter to the soil, may also help to prevent soil erosion from the mountain slopes. Such trees also act as windbreaks and protect the soil from erosion. Terrace farming, making small bunds, growing tussock grasses along the border and bunds, and applying of manure based on the nature of the soil are some of the ways that help to maintain the nutrients in the soil and ultimately the soil fertility [29].

For the day-to-day requirement of plant resources, they set up home gardens, which also trap a number of ecosystem services in the vicinity of their dwelling places. Home gardens not only support dietary diversity but also help in maintaining the social fabrics of the community while exchanging the produce grown in the gardens. Besides, the home gardens help in ex situ conservation of genetic diversity of useful plant species.

Other than the home gardens, the tribal communities have evolved another traditional in situ conservation approach in the form of earmarking sacred groves where they worship their local deities [32]. Each sacred grove is named after the deity, which is believed to be dwelling in the respective sacred grove. A total of 19 such deities are recorded in the buffer zone of PBR and are worshipped by the local people. None of the plant species are harvested or collected from the sacred groves. Therefore, the sacred groves remain the islands of rich plant genetic and species diversity.

Apart from conservation of plant diversity, the tribal people in PBR have accumulated knowledge on maintaining soil fertility and conservation. Over the centuries, they have adopted various traditional practices, including crop rotation, burning of crop residues, planting tree species, and frequently applying farmyard manure, which finally help in maintaining and sustaining the soil fertility [12]. Besides, the traditional conservation and management practices are well knitted and interwoven with the cultures, belief systems, and available resources.

3.5. Wide-Reaching Concerns of Tribal TEK. PBR being situated in the middle of eastern and southern India, it possesses the components of both areas, which finally shape its rich biodiversity and cultural milieu. The biogeographical diversity of PBR and subsequent evolution of TEK as a source of survival reflects the potential of TEK in human development. Moreover, the TEK has given a platform for the evolution of various ethos of nature conservation. Therefore, researchers inclined to sustainability of nature and natural resources have been trying to evaluate the TEK

occupied by traditional knowledge holders across the world [33]. There are reports on advocating applicability and integration of TEK to ensure ecosystem stability and resilience, land use management, soil fertility, soil water regimes, global change, livelihood generation, and poverty eradication [33, 34]. In addition, the TEK demands recognition and respect as a whole including its philosophical bases for the purpose of ecosystem sustainability [14].

The natural resources as collected and used by the tribal communities have an important sociocultural epistemology. They are generally collected by applying some specific and traditionally developed technology, which is mainly governed by social institutions and norms [13]. The restrictions are imposed on the gathering of plant species during the particular period, considering the fact that periods of restriction on plant resource use may help to continue species reproduction and ensure the sustained availability of the resources [35]. Centuries of experiences on the consequences of early resource use modes and exigencies of ecosystem's sustainability are known to reorder the social behavior of ethnic communities towards sustainable resource use [36].

Over the years, values engrained in TEK have paved the way to accept this knowledge system across the disciplines, and many agriculturalists, pharmacologists, and water engineers are influenced by the traditional practices of tribal communities [37]. Traditional knowledge on the use and significance of plants for food and medicine, as discovered and accumulated by the tribal communities, has been the source of many modern medicines and nutritious food products [38]. The World Health Organization (WHO) has also projected that worldwide around 3.5 billion people in developing countries rely on plant-based medicines for primary healthcare. For various reasons, tribal communities still rely on traditional medicines. The cultural acceptability is one of the main causes, besides the unavailability of modern medical facilities [39].

The major part of TEK is open to all the members of the community if they desire to learn; however, some specific knowledge may only be passed on to next generations after following certain institutional mechanisms. TEK is transferred to generations through the transmission of cultures, practices, technologies, and belief systems, which may and may not be always accepted by younger generations. Over the years, there has been a continuous decline in some elements and sections of TEK. British colonial land use policies in India are also blamed for eroding much of the traditional resource use norms, most of which are continued in post-independence India along with industrial development [35, 36]. The study in PBR corroborates the fact that TEK is in transition, as reported by Sillitoe [40] and Berkes [9], which raises serious concerns for historical involvement of communities in nature conservation.

The traditional knowledge of tribal communities offers ideas for developing and contributing to the crafting of instruments for sustainable management practices and nature conservation, as evident from the study in PBR. Besides, the traditional knowledge has a great potential to strengthen the agriculture and health sectors, as the tribal communities have accumulated a fair amount of knowledge in such sectors. For centuries, traditional knowledge has provided the basis for problem-solving strategies for tribal groups; therefore, at present, there are worldwide concerns about the importance and preservation of traditional knowledge in communities for various causes.

4. Conclusion

The present study reveals that traditionally the livelihood of tribal people is mainly revolved around forest resources and marginal agriculture. They have adopted specific belief systems so that the methods, tools, and technologies for utilization and management of natural resources. At present, the traditional knowledge and practices as adopted by the tribal groups are undergoing transformation due to a number of causes. A part of the traditional knowledge is commercialized whereas the other part, which is perceived as less valuable, is ignored. Nature and natural resource conservation are not segmented aspects for tribal communities but are engrained in their habits, customs, and belief systems so the TEK must be exercised in a holistic way. The doctrines of TEK offer some valuable guiding principles for devising policies for both nature and cultural conservation. Realizing the ongoing complexities in nature conservation and sustainability of natural resources, there is a need to have a coherent and practical policy on conservation of nature as well as cultural resources as they complement each other.

Data Availability

The data are available from the corresponding author upon request and are included in the manuscript.

Conflicts of Interest

The author declares that there are no conflicts of interest.

Acknowledgments

This study was partially funded by the Indian Institute of Forest Management for field data collection. Author wishes to thank the Director Indian Institute of Forest Management for logistic support. The help extended by N. S. Dungriyal, Director, Satpuda National Park, Madhya Pradesh and other officials of Pachmarhi Biosphere Reserves is greatly acknowledged. Author expresses deep sense of gratitude to the villagers of buffer zone areas of Pachmarhi Biosphere Reserves for their co-operation and support during the course of this study.

References

[1] F. S. Chapin, E. S. Zavaleta, V. T. Eviner et al., *Consequences of changing biodiversity*, vol. 405, no. 6783, pp. 234–242, 2000.

[2] M. Lenzen, D. Moran, K. Kanemoto, B. Foran, L. Lobefaro, and A. Geschke, "International trade drives biodiversity threats in developing nations," *Nature*, vol. 486, no. 7401, pp. 109–112, 2012 Jun.

[3] I. Kant, *Duties to Animals and Spirits*, Harper & Row, New York, 1963.
[4] S. Sakar, *Biodiversity and Environmental Philosophy*, Cambridge University Press, New York, 2005.
[5] A. Bosworth, N. Chaipraditkul, M. M. Cheng et al., *Ethics and Biodiversity Asia and Pacific Regional Bureau for Education*, UNESCO Bangkok, Thailand, 2011.
[6] F. Aggestam, "Framing the ecosystem concept through a longitudinal study of developments in science and policy," *Conservation Biology*, vol. 29, no. 4, pp. 1052–1064, 2015.
[7] H. Kopnina, H. Washington, B. Taylor, and J. J. J Piccolo, "Anthropocentrism: more than just a misunderstood problem," *Journal of Agricultural and Environmental Ethics*, vol. 31, no. 1, pp. 109–127, 2018.
[8] F. Berkes, "Traditional ecological knowledge in perspective," in *Traditional Ecological Knowledge: Concepts and Cases*, J. T. Inglis, Ed., pp. 1–10, International Development Research Centre, Ottawa, Canada, 1993.
[9] F. Berkes, *Sacred Ecology: Traditional Ecological Knowledge and Resource Management*, Taylor & Francis, Philadelphia, PA, 1999.
[10] M. Gadgil and F. Berkes, "Traditional resource management systems," *Resource Management & Optimization*, vol. 18, pp. 127–141, 1991.
[11] F. Berkes, "Rethinking community-based conservation," *Conservation Biology*, vol. 18, no. 3, pp. 621–630, 2004.
[12] C. P. Kala, *Traditional Ecological Knowledge and Conservation of Ethnobotanical Species in the Buffer Zone of Pachmarhi Biosphere Reserve, Madhya Pradesh*, Indian Institute of Forest Management, Bhopal, India, 2012.
[13] M. D. Warren, "Using indigenous knowledge for agriculture and rural development: current issues and studies," *Indigenous Knowledge and Development Monitor*, vol. 1, no. 1, pp. 7–10, 1993.
[14] N. J. Turner, M. B. Ignace, and R. Ignace, "Traditional ecological knowledge and wisdom of aboriginal peoples in British Columbia," *Ecological Applications*, vol. 10, no. 5, pp. 1275–1287, 2000 Oct.
[15] C. P. Kala, "Traditional system of medicine and management of the COVID-19 pandemic in India," *Studies on Ethno-Medicine*, vol. 15, no. 3-4, pp. 126–136, 2021a.
[16] UNESCO, "UNESCO Biodiversity," 2017, http://www.unesco.org/new/en/natural-sciences/special-themes/biodiversity/biodiversity-culture/biosphere-reserves-learning-sites/.
[17] M. Lehtonen, "The environmental-social interface of sustainable development: capabilities, social capital, institutions," *Ecological Economics*, vol. 49, no. 2, pp. 199–214, 2004.
[18] EPCO, *Pachmarhi Biosphere Reserve*, Environmental Planning and Co-ordination Organization, Bhopal, 2001.
[19] C. P. Kala, "Forest structure and anthropogenic pressures in the Pachmarhi biosphere reserve of India," *Journal of Forestry Research*, vol. 26, no. 4, pp. 867–874, 2015.
[20] A. Agrawal, "Dismantling the divide between indigenous and scientific knowledge," *Development and Change*, vol. 26, no. 3, pp. 413–439, 1995.
[21] A. K. Bhattacharya, *Forestry for the Next Decade: Managing Thrust Areas*, Concept Publishing Company, New Delhi, 2007.
[22] United Nations, *Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from Their Utilization to the Convention on Biological Diversity*, https://www.cbd.int/abs/, 2011.
[23] C. P. Kala, "Indigenous uses and sustainable harvesting of trees by local people in Pachmarhi Biosphere Reserve of India," *International Journal of Medicinal and Aromatic Plants*, vol. 1, no. 2, pp. 153–161, 2011.
[24] C. P. Kala, "Harvesting and supply chain analysis of ethnobotanical species in the Pachmarhi Biosphere Reserve of India," *American Journal of Environmental Protection*, vol. 1, no. 2, pp. 20–27, 2013.
[25] C. P. Kala, "Important gum yielding species Anogeissus latifolia (Roxb.) Bedd., Boswellia serrata Roxb. and Sterculia urens Roxb.: ethnobotany, population density and management," *Applied Ecology and Environmental Sciences*, vol. 4, no. 3, pp. 61–65, 2016.
[26] S. H. Kim, S. R. Lim, S. J. Hong et al., "Effect of ethephon as an ethylene-releasing compound on the metabolic profile of Chlorella vulgaris," *Journal of Agricultural and Food Chemistry*, vol. 64, no. 23, pp. 4807–4816, 2016.
[27] C. P. Kala, "Traditional farming system of Gond and other communities in the Pachmarhi biosphere reserve of India," *Applied Ecology and Environmental Sciences*, vol. 3, no. 5, pp. 140–145, 2015.
[28] C. P. Kala, "Home gardens and management of key species in the Pachmarhi Biosphere Reserve of India," *Journal of Biodiversity*, vol. 1, no. 2, pp. 111–117, 2010.
[29] C. P. Kala, "Traditional ecological knowledge on characteristics, conservation and management of soil in tribal communities of Pachmarhi Biosphere Reserve, India," *Journal of Soil Science and Plant Nutrition*, vol. 13, no. 1, pp. 201–214, 2013.
[30] S. K. Chaudhari, P. P. Biswas, and H. Kapil, *Soil health and fertility. in The Soils of India 2020*, Springer, Berlin, Germany, 2020.
[31] T. J. Purakayastha, H. Pathak, S. Kumari et al., "Soil health card development for efficient soil management in Haryana, India," *Soil and Tillage Research*, vol. 191, pp. 294–305, 2019 Aug 1.
[32] C. P. Kala, "Traditional ecological knowledge, sacred groves and conservation of biodiversity in the Pachmarhi Biosphere Reserve of India," *Journal of Environmental Protection*, vol. 2, no. 7, pp. 967–973, 2011b.
[33] P. S. Ramakrishnan, "What is traditional ecological knowledge?," in *Traditional Ecological Knowledge for Managing the Biosphere reserve in South and Central Asia*, P. S. Ramakrishnan, R. K. Rai, R. P. S. Katwal, and S. Mehndiratta, Eds., pp. 3–12, Oxford University Press, New Delhi, 1993.
[34] R. K. Brook and S. M. McLachlan, "On Using Expert-Based Science to "Test" Local Ecological Knowledge," *Ecology and Society*, vol. 10, no. 2, 2005, http://www.ecologyandsociety.org/vol10/iss2/resp3/.
[35] D. Deb and K. C. Malhotra, "Conservation ethos in local traditions: the West Bengal heritage," *Society & Natural Resources*, vol. 14, no. 8, pp. 711–724, 2001.
[36] M. Gadgil and R. Guha, *The Fissured Land: An Ecological History of India*, Oxford University Press, Delhi, 1992.
[37] B. Rajasekaran and M. B. Whiteford, "Rice-crab production system: the role of indigenous knowledge in designing food security policies," *Food Policy*, vol. 18, no. 3, pp. 237–247, 1992.
[38] C. P. Kala, "Ethnic food knowledge of highland pastoral communities in the Himalayas and prospects for its sustainability," *International Journal of Gastronomy and Food Science*, vol. 23, Article ID 100309, 2021b.
[39] C. P. Kala, *Medicinal Plants and Sustainable Development*, Nova Science Publishers, New York, 2011c.
[40] P. Sillitoe, "The development of indigenous knowledge," *Current Anthropology*, vol. 39, no. 2, pp. 223–252, 1998.